THE REPTILES OF LORD HOWE ISLAND

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(Plates I, II)

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Synopsis

Three species of lizards are the only terrestrial reptiles recorded from Lord Howe Island. Of these, only the gecko *Phyllodactylus guentheri* Boulenger and the endemic skink *Leiolopisma lichenigera* (O'Shaughnessy), both of which are redescribed, are currently known to occur on the island.

Although both lizards are abundant on the small islands lying off-shore from Lord Howe Island (including Ball's Pyramid, from which both species are here recorded for the first time), they are now uncommon on the main island and confined to a small specialized habitat. The latter is described.

Records of the gecko *Gehyra oceanica* (Lesson) from Lord Howe Island are shown to be in doubt.

Introduction

Lord Howe Island (Fig. 1, Pl. I, A, B) is a crescent-shaped island roughly 7½ miles long and averaging about one mile in width, and is located approximately 440 miles east-north-east of Sydney, New South Wales. Its highest point (Mount Gower) rises to 2,836 feet above sea-level. The island is the central portion of a platform which has an average depth of about 50 fathoms. Standard (1961) considered that this platform was formed by wave action during the Pleistocene.

Lord Howe Island has long held great interest for the biologist, largely because of its isolation and the relatively high order of endemicity of its plants and animals. Until its discovery by Lt. Henry Lidgbird Ball in 1788 (only two weeks after the founding of the first Australian settlement at Port Jackson), Lord Howe Island had not known human occupation.

The history of the island has been well documented by Nicholls (1938) and Hindwood (1940). Oliver (1917) gives an excellent account of the plants of the island, while Standard (1963) gives a full account of its geology. Standard (1961) discusses Lord Howe Island in relation to the submarine geology of the Tasman Sea. Excellent general accounts of the island and its natural history are given by McCulloch (1921), Pope (1949, 1959, 1960) and Paramonov (1958, 1960 and 1963). The latter discussed briefly the status and habits of the island's reptiles. More recent treatment of the birds is given by Hindwood and Cunningham (1950) and McKean and Hindwood (1965). Squires (1963) provided Carbon-14 datings of 20,700 years and more than 38,500 years for two samples from the Fossil Dune Sequence on Lord Howe Island, from which specimens of the large extinct turtle *Meiolania platyceps* have been taken.

Significant changes have been wrought in the original environment of Lord Howe Island since European occupation. Eight species of land birds have become extinct (Hindwood, 1940; McKean and Hindwood, 1965). The endemic phasmid *Dryococelus australis* was also believed to be probably extinct (Gurney, 1947), but this insect was recently rediscovered on Ball's Pyramid, south of Lord Howe Island (McAlpine, 1966). There seems little doubt that this insect is extinct on the main island.

The major disruption to the ecology of the island is thought to have been brought about by the chance introduction of the Black Rat (*Rattus rattus*) in 1918. The Burns Philp steamship *Makambo* ran aground on 14th June of that year and rats apparently accompanied the loads of fruit and copra which were thrown overboard and washed ashore. At least, it was immediately after this event that the islanders first noticed the presence of rats. Within a short time the numbers of these animals had reached plague proportions and were having a disastrous effect on the island's principal industry, the harvesting and export

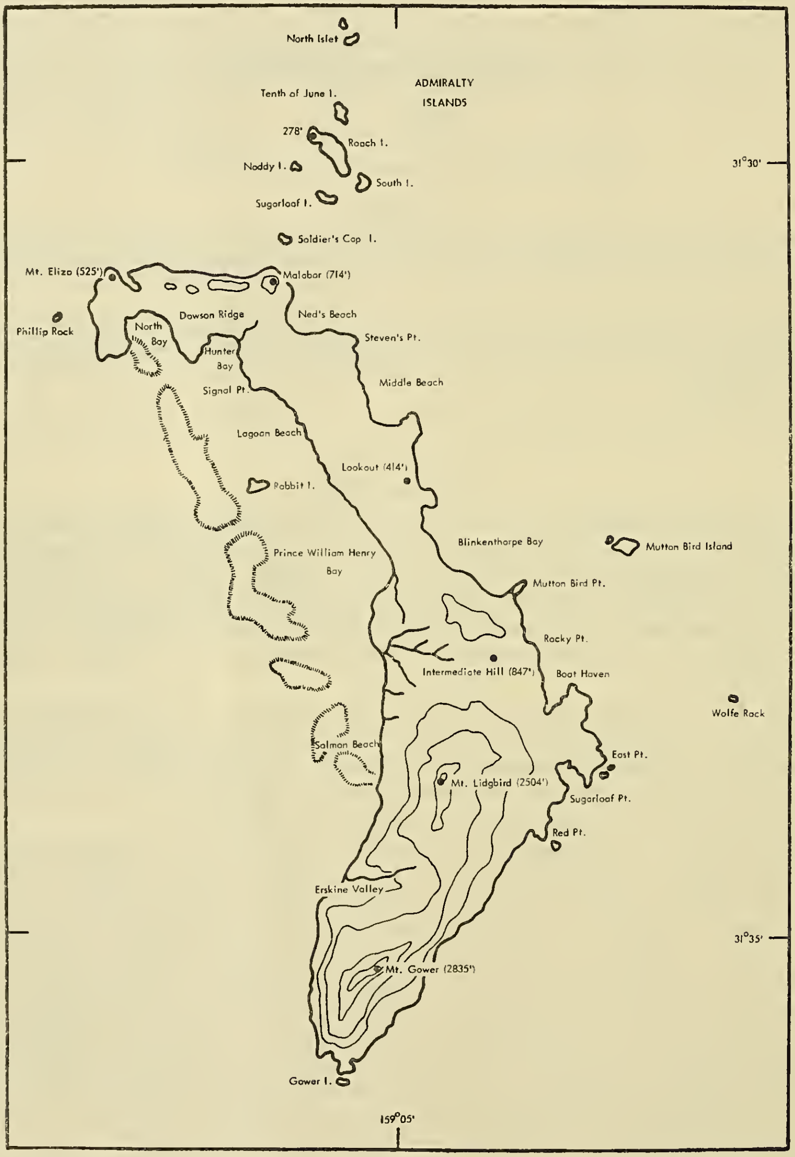

Fig. 1. Map of Lord Howe Island showing topography and principal localities. Contour lines are at 500 ft. intervals.

of the seeds of the endemic palms (*Howea* spp.). For many years a bounty was offered on rats, but at the time of writing the number of rats is maintained at a relatively low level due to systematic poisoning by the Island Board.

Prior to the introduction of the Black Rat, goats and pigs had been released and these were soon running wild (and still do) in the uninhabited parts of the island.

Hindwood (1940) records that only three species of land birds were extinct when rats were first introduced in 1918, but by 1935 an additional five species had vanished. The extent to which rats were responsible for eliminating these birds is difficult to assess, but there seems little doubt that on the main island rats exterminated the endemic phasmid mentioned above.

One of the aims of the author's visit to Lord Howe Island was to determine whether the reptile fauna had been influenced significantly by any of those factors which had brought about changes in other animal groups. There was, in fact, some evidence to suggest that changes had occurred in the reptile population, for recent reports from the island suggested that lizards were only infrequently seen and difficult to collect on the main island, despite the fact that they were extremely common on Rabbit Island (Pl. I, C). The latter is a low island, about 250 yards long and 118 feet high, lying within the lagoon less than half a mile off-shore.

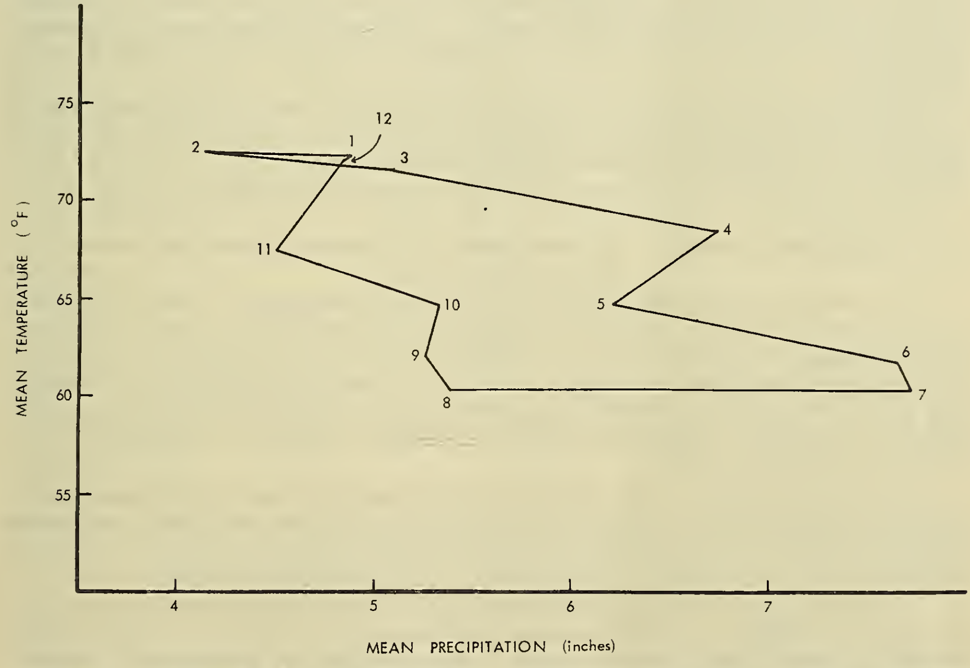

Fig. 2. Climatograph for Lord Howe Island based on data supplied by the Commonwealth Bureau of Meteorology. Months are indicated by numbers.

No attempt has been made to treat the marine reptiles of Lord Howe Island. The sea-snake fauna of north-eastern Australia is a rich one, and although many species probably occur in the waters near Lord Howe Island, I can find no reliable records. Indeed, such records would probably bear little relationship to the number of forms occurring in the area.

Similarly, all of the marine turtles known from the Great Barrier Reef probably frequent the waters of Lord Howe Island from time to time, but no reliable records are available. However, it is interesting to note that turtles, presumably the Green Turtle (*Chelonia mydas*), once nested on Lord Howe Island and provided a valuable source of food for the early visitors and colonists. Phillip (1789) notes that turtles were nesting in abundance in March 1788.

Turtles no longer breed on the island and they are only infrequently seen in the surrounding seas. The disappearance of the turtle colony is generally attributed to excessive hunting, but this explanation is not entirely satisfactory. Turtles have been hunted intensively at their breeding sites for many years in many places throughout the world, and although serious depletion of breeding populations has often resulted, the total extermination of such populations has not proved to be readily accomplished. However, it may be that the isolation of Lord Howe Island prevented recolonization after its relatively small breeding community was reduced to a level which was no longer viable.

Situated some 10 nautical miles to the south of Lord Howe Island is Ball's Pyramid, a large eroded remnant of volcanic rock (of the same series as the Mt. Lidgbird volcanics of Standard, 1963) which rises to a height of 1,811 feet. This rock is still virtually unexplored biologically and was first scaled in 1965 by a party from Sydney Rock Climbing Club. Two earlier attempts by the same club were unsuccessful, and although no biological collections were made, on the second of these trips photographic records of the " extinct " Lord Howe Island phasmid *Dryococelus australis* (McAlpine, 1966) and the scincid lizard *Leiolopisma lichenigera* (see later discussion) were made. Another climbing party in February 1969 collected specimens of both *Leiolopisma lichenigera* and *Phyllodactylus guentheri*.

Ball's Pyramid sits on a shallow platform which is separated from that of Lord Howe Island by depths of more than 2,000 feet and was probably never connected to Lord Howe Island (Standard, 1963).

Basic climatological data for Lord Howe Island is presented in Fig. 2.

THE PRESENT STATUS OF THE RECENT REPTILES RECORDED FROM LORD HOWE ISLAND

The only recent terrestrial reptiles recorded from Lord Howe Island are three species of lizards, only one of which—the skink *Leiolopisma lichenigera* (O'Shaughnessy)—is believed to be endemic. The other two species are the geckos *Phyllodactylus guentheri* Boulenger and *Gehyra oceanica* (Lesson). The former has been recorded only from Lord Howe Island, Norfolk Island and north-western Australia, whereas the latter is widely distributed throughout the south-west Pacific region.

Loveridge (1934) considered that *Leiolopisma lichenigera* (O'Shaughnessy), described originally from Lord Howe Island, was conspecific with *Leiolopisma cuprea* (Gray). The latter species was described from a specimen without locality data. The validity of Loveridge's action is discussed below.

The first record of the gecko *Gehyra oceanica* from Lord Howe Island is that of Boulenger (1885), who listed a male specimen in the British Museum (Natural History) from " Lord Howe's Island ", collected by J. Macgillivray. Subsequently Etheridge (1889) and Ogilby (1889) included *Gehyra oceanica* in the fauna of Lord Howe Island, but apparently based their record solely on the Macgillivray specimen listed by Boulenger. The Australian Museum expedition about which Etheridge and Ogilby were writing did not obtain specimens of this species.

Paramonov (1960), presumably following Etheridge and Ogilby, included *Gehyra oceanica* in the Lord Howe Island fauna, while Mitchell (1965) records this species from Lord Howe Island on the basis of Zietz's (1920) record and " specimens in the Australian Museum collection ". Zietz appears to have based his record on the British Museum specimen recorded by Boulenger, while there is one specimen (no. 4931) in the Australian Museum which is ostensibly a *Gehyra oceanica* from Lord Howe Island. However, as this specimen has apparently been lost (it was collected in the late 1800's) and as its identification and locality are based on a series of ambiguous ditto marks below entries for *Gehyra oceanica* from Fiji and *Phyllodactylus guentheri* from Lord Howe Island, I regard the record as suspect.

As *Gehyra oceanica* has been recorded from New Zealand (McCann, 1955) it might seem that excessive pains are being taken to discredit the Lord Howe Island record for this species. However, as it is normally common wherever it occurs, its apparent absence from Lord Howe Island appeared to the author to be sufficient grounds for questioning the validity of the earlier records.

Macgillivray, as naturalist on the voyage of the *Herald*, spent some months on Lord Howe Island (Macgillivray, 1852–55). However, as there were, at the time of the *Herald's* voyage, three other islands known as " Lord Howe Island " in the area covered by the ship's travels (one, now known as Ontong Java in the Solomon Islands ; one, now known as Mopeha Island, in the Society Islands ; and one in the Santa Cruz Islands), a request was made to Miss A. G. C. Grandison of the Herpetology Department of the British Museum (Natural History) to examine the original record of Macgillivray's specimen. Miss Grandison (*in litt.*) reports : " In our collection are four specimens given as coming from (a) Fiji, (b) Lord Howe Island, (c) two specimens from Fiji ; but reference to the original register indicates that the specimen (a) has no locality, was part of the Macgillivray collection but was purchased from Cuming. The specimen (b) is given as having been collected on the Isle of Pines (New Caledonia) and not Lord Howe Island and only the two specimens (c) seem to be correct in their locality." Hence the Macgillivray specimen, on which is based virtually all Lord Howe Island records of this species, did not in fact come from that island. For this reason it seems advisable to remove *Gehyra oceanica* from the list of the island's fauna until such time as it is clearly shown to occur there. The remaining two species are redescribed below ; S.D. represents the standard deviation of the sample.

Leiolopisma lichenigera (O'Shaughnessy)

(Plate II, C)

Mocoa lichenigera O'Shaughnessy, 1874. *Ann. Mag. Nat. Hist.*, Series 4, 13 : 298.

Holotype—British Museum (Natural History) No. $\begin{matrix}55.8.16.12\\1946.8.16.27\end{matrix}$ from Lord Howe Island, N.S.W.

Description : Habitus moderate ; mean adult snout-vent length 78 mm., maximum recorded snout-vent length 96 mm. (♀, R26037) ; the snout-vent/axilla groin ratio averages 1·93 (range 1·74–2·33, S.D.=0·079) ; limbs well-developed, the snout-vent/forelimb length ratio averages 3·90 (range 3·50–4·35, S.D.=0·192) while the snout-vent/hindlimb length ratio averages 2·99 (range 2·51–3·48, S.D.=0·167) ; the adpressed limbs fail to meet ; snout moderately angular ; the head is distinctly swollen posteriorly due to the well-developed muscles in the quadrate region ; lower eyelid with an undivided transparent disc ; supranasals absent ; nostril pierced in a partly divided nasal, a deep groove dividing the scale posterior to the nostril ; frontonasal much broader than long, in contact with the rostral anteriorly and the frontal posteriorly ; prefrontals widely to narrowly separated ; frontal only slightly longer than broad, about as long as frontoparietal and interparietal together, and in contact with the two anterior supraoculars ; 4 supraoculars, although in one specimen the two anterior supraoculars on one side are partially fused ; 2 loreals ; 7 supralabials, the 4th, 5th and 6th below the eye but totally or partially excluded from the granules of the lower eyelid by a series of small suboculars ; 5–6 infralabials ; either a single pair of nuchals or no discernible nuchals (of 44 specimens examined for this character, 59% possessed one pair of enlarged nuchal shields, 9% possessed an enlarged nuchal on one side only, and 32% lacked any enlarged nuchals); 36–46 scale rows around the middle of the body (mean 42·7, S.D.=1·96); 86–109 rows of scales along the mid-dorsal line from the parietals to the base of the tail (mean 99·4, S.D.=3·90); 15–21 lamellae under the fourth toe (mean 18·0, S.D.=1·05); ear-opening vertically elliptic, its long axis from 1⅓–2 times the diameter of the transparent disc in the lower eyelid.

Dorsal surface, including the head and limbs, rich bronzy brown to olive with scattered dark brown and light brown flecks and streaks. The darker flecks tend to disappear in adult animals, so that the lighter ones predominate in large individuals. A narrow (usually less than 1 scale in width) brown band on either side commencing at the nostril and extending below the canthus to the eye. This band continues behind the eye and extends above the ear and along the dorso-lateral surface of the body to the tail, and, where the latter is original, along the length of the tail.

This dark dorso-lateral band may continue with equal intensity to the base of the tail, but in some specimens it becomes obscure posterior to a point about midway between snout and vent.

The narrow dark dorso-lateral band is bordered below by a dark brown area, about 3–4 scales in width, in which scattered groups of light-coloured scales form irregular blotches or indistinct oblique bars that are directed downwards and backwards. This region fades into the light grey or brown ventro-lateral colour, which in turn merges with the cream ventral surface. The latter, in living specimens, is often brilliant orange or lemon-yellow. The throat, especially in the labial region, is usually flecked with light grey or brown. The upper labials, especially in juveniles, may be alternately barred with brown and light grey. In life, regenerated tails are usually bright orange.

Distribution: *Leiolopisma lichenigera* is known only from Lord Howe Island and the small islands lying off-shore from it (including Ball's Pyramid).

Material Examined: Australian Museum, Sydney: R26033–R26037, R26057, R26074, R26086, Roach Islet, Lord Howe Island; R18919–R18920, R18979–R18983, R26048–R26052, Rabbit Island, Lord Howe Island; R2546, R7923–R7928, R10942–R10946, R26058–R26071, Lord Howe Island; R29052–R29057, Ball's Pyramid. Dominion Museum, Wellington: R599, Lord Howe Island; R768, north end of Lord Howe Island. Museum of Comparative Zoology, Harvard: 35459–62, 35464–69, 93776–80, Lord Howe Island.

Remarks: Loveridge (1934) placed *L. lichenigera* in the synonymy of *Leiolopisma cuprea* (Gray), a species whose type locality is unknown. Boulenger (1887), who had the holotypes of both species before him, differentiated the two species on the following characters:

lichenigera	*cuprea*
4 supraoculars	3 supraoculars
42 mid-body scale rows	36 mid-body scale rows

Loveridge had a series of 18 specimens, all of which possessed 4 supraoculars and with mid-body scale row counts ranging from 36–46 (mean 42). He suggested that the 3 supraoculars in the type of *cuprea* were abnormal. As *L. lichinigera* is known only from Lord Howe Island, Loveridge's action implied that the type of *L. cuprea* came from this locality.

Of the 69 specimens listed above, only one shows any deviation from the four supraoculars count. This specimen (R18919) has only 3 supraoculars (caused by partial fusion of the first and second) on the right-hand side. The mid-body scale row count varies from 36 to 46, averaging 42·7.

In the scincid genus *Emoia*, Brown (1953, 1954) made good use of the number of scale rows along the mid-dorsal line, from parietals to tail base, as a taxonomic character. This count was made on all of the above specimens of *L. lichenigera* and averaged 99·7 (range 85–109, S.D. of sample 3·93).

The holotype of *L. cuprea* has three supraoculars on each side, 36 rows of scales around the middle of the body and about 84 rows of scales from the parietals to the base of the tail (damaged parietal region prevents a precise count). It is in poor condition, being so badly discoloured that the original colour and pattern are not discernible. The nostril is pierced in an otherwise immaculate nasal, whereas the nasal is strongly grooved or divided posteriorly in all specimens of *L. lichenigera* examined.

A specimen (M.C.Z. 35460) cited by Loveridge (1934) is the only one found to possess a mid-body scale row count below 40. This specimen has only 36 rows of scales around the middle of the body, and has only 86 rows of scales from parietals to base of tail. Loveridge considered that this exceptional individual bridged the gap between *cuprea* and *lichenigera*, but as the latter is known only from the one island locality it seems unlikely that either geographic or individual variation could account for the differences between this species and the type specimen of *cuprea*.

In view of this decision to regard *L. cuprea* and *L. lichenigera* as distinct species, an attempt was made to determine with what other known species *L. cuprea* might be conspecific. In its colour, pattern, the undivided nasal and the shape and disposition of many head scales (notably the labials, loreals and preoculars) it appears to be most closely allied to the Leiolopismas of New Zealand. However, it differs from the described species in enough features (especially its supraocular count) to cast considerable doubt as to its relationships. It is therefore relegated to the status of a *nomen dubium*.

Phyllodactylus guentheri (Boulenger)
(Plate II, D)

Phyllodactylus guentheri Boulenger, 1885. *Cat. Liz. Brit. Mus.*, 1: 90, pl. 7, fig. 3.

Syntypes: (5), British Museum (Natural History) from Champion Bay, N.W. Australia (67.2.19.18), Lord Howe's Island (56.7.7.19) and Norfolk Island (62.1.6.29–31).

Description: Habitus stout; mean adult snout-vent length 71·2 mm., maximum recorded snout-vent length 91 mm. (R29193); limbs well developed; the snout-vent/forelimb length ratio averages 3·09 (range 2·66–3·70, S.D. = 0·223) while the snout-vent/hindlimb length ratio averages 2·47 (range 2·00–2·75, S.D. = 0·155); the adpressed limbs overlap; head relatively deep; canthus rounded; eye moderate, its diameter equal to about half the distance from eye to tip of snout; rostral rectangular, about twice as wide as deep and lacking a median crease; nostril directed backwards and upwards and surrounded by the rostral, first labial and four other scales, the upper one or two of which are considerably enlarged; several small scales between these enlarged "supranasals"; scales on top and sides of snout larger than dorsals; but the latter and the scales on the head are subequal; 7–9 supralabials; 7–9 infralabials; the anterior labials are largest, and all are much larger than the adjacent scales; mental roughly pentagonal, about the same size as adjacent infralabials; anterior and lateral gular scales much larger than the remainder; a distinct gular fold; ear-opening relatively small, its maximum diameter about two-thirds that of the eye; dorsal and lateral surfaces of body covered with small, juxtaposed conical scales which are much smaller than the flat, slightly-imbricate ventrals; more than 10 scales in the middle of the back in a distance equal to the diameter of the eye; number of scale rows around middle of body averages 138·4 (range

119–160, S.D. = 7·87); limbs covered above with conical scales somewhat larger than those on the dorsum; lower surfaces of limbs with flat, slightly imbricate scales like those on the venter; digits moderately dilated, the distal expansion of the 4th toe greatest, its width about equal to the maximum diameter of the ear-opening; each digit with a pair of enlarged pads or lamellae distally, between which is a large claw; the sheath from which each claw projects extends to the edge of the distal lamellae or beyond; there are 9–12 undivided lamellae under the 4th toe (mean 10·23, S.D. = 0·815); these are largest basally and are separated from the enlarged distal lamellae by from 3–7 rows of small scales; tail covered with flat, slightly imbricate scales which are arranged in fairly regular rings and are largest ventrally; the latter are about twice as large as those on the upper surface of the tail, these latter more or less equaling in size the scales on the venter; preanal and femoral pores absent; males with a swollen post-cloacal region on each side of which is a cluster of 3–4 slightly enlarged rounded tubercles.

Colour and pattern extremely variable. Dorsal surface medium grey or brown (the latter colour predominates in preserved specimens) usually with a dull orange (in life) or light brown vertebral stripe which extends from the nape to the base of the tail. This stripe usually divides a series of irregular, transverse dark grey or dark brown bands which typically number six between the nape and the base of the tail. In many specimens this vertebral stripe may be indistinct or absent, while the irregular transverse bands may break up to such an extent that the dorsal surface is simply variegated with light and dark grey or brown. The head is often darker than the ground colour of the body. Labials mottled with light grey or brown; sides and upper surfaces of the limbs are usually grey or brown mottled with irregular darker markings, while the ventral surface is grey or off-white, each individual scale peppered with dark grey. The scales of the throat are more richly peppered than those of the body.

The tail, where original, is usually alternately banded with irregular dark and light grey or brown, the bands not extending on to the ventral surface; in some specimens these bands break up to form irregular mottling. Regenerated tails are usually light brown or grey with scattered darker scales. Underside of tail light grey.

No major differences in colour and pattern can be observed between the Lord Howe Island and Norfolk Island populations. However, there is a definite tendency for the darker transverse markings to be narrower and less conspicuous in the Norfolk Island specimens, while old adults from the latter locality tend to have the pattern reduced to scattered dark flecks or spots.

The colour and pattern of hatchlings from Lord Howe Island appear to be fairly constant. The dorsal ground colour is rich olive-brown, speckled with darker brown; there is a light salmon-coloured patch over each eye and an indistinct, broken vertebral stripe of a rich salmon colour; the tail, especially distally, is rich salmon with dark brown bands; the venter is white with numerous grey flecks; the ventral surface of the tail is salmon-coloured.

Distribution: *Phyllodactylus guentheri* is known from Norfolk Island and Lord Howe Island and their small off-shore islands. In his original description Boulenger lists one of the type series from "Champion Bay, N.W. coast of Australia", but this record appears to be in error. Champion Bay lies within the known range of *Phyllodactylus marmoratus* and is far removed from the other localities in which *P. guentheri* is known to occur. No specimens of the latter have subsequently been recorded from mainland Australia. However, Miss Grandison has checked the original data associated with this specimen and can find no reason for doubting its validity.

Material Examined: Australian Museum, Sydney: 4930, R360, R3350, R4542, R5581, R5583–4, R8043, R26072–3, Lord Howe Island; R26038–47, R26085, Roach Island, Lord Howe Island; R18984–6, R19298–9, R26053–6, Rabbit Island, Lord Howe Island; R4270–3, R4275–7, R4919, R5594, R19301, R29192–4, Norfolk Island; R29058–9, Ball's Pyramid, Lord Howe Island. Dominion Museum, Wellington: R1–8, R780–2, Norfolk Island.

Remarks: This species has long been in the synonymy of *Phyllodactylus marmoratus*, the only other Australian member of this genus (Loveridge, 1934). However, *P. guentheri* is very distinct from *P. marmoratus*, and can be readily distinguished from the latter:

Phyllodactylus marmoratus: Width of distal expansion of 4th toe at least twice the maximum diameter of the ear-openings; scales relatively large and regular; 84–96 mid-body scale rows (mean of 21 specimens 90·4, S.D.=3·7); sheath of claw on each digit does not extend to edge of distal lamellae (Fig. 3).

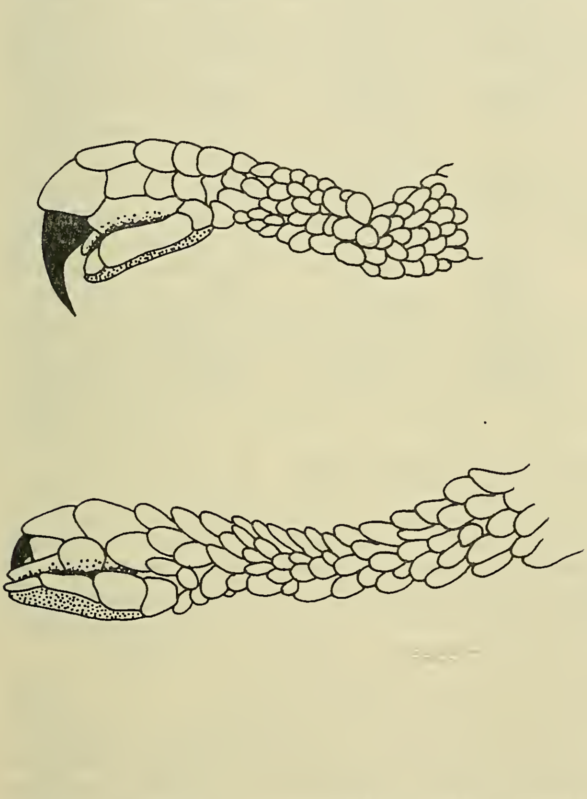

Fig. 3. Lateral and dorsal views of distal portions of the fourth toes of *Phyllodactylus guentheri* (upper) and *P. marmoratus* (lower).

Phyllodactylus guentheri: Width of distal expansion of 4th toe about equal to the maximum diameter of the ear-opening; scales on most parts of body small, tubercular; 119–160 mid-body scale rows (mean 138·4); sheath of claw of each foot extends to edge of distal lamellae or beyond (Fig. 3).

Unfortunately the material available for study is inadequate for an effective analysis of intraspecific variation in meristic and other characters. Nevertheless, there are indications that the populations on the different islands do differ from one another at a measurable level. For example, the two specimens from Ball's Pyramid have much longer limbs than specimens from other localities. The data in Table 1 are presented, therefore, with a view to indicating the potential value of using these island populations for micro-evolutionary studies. There seems little doubt that barriers to dispersal and interchange between the various island populations are so effective that gene flow is reduced to a mere trickle, if any, and that each island population is evolving almost entirely independently of the others.

TABLE 1

	Mid-body Scale Rows	Lamellae under Fourth Toe	Snout-vent/ Axilla-groin	Snout-vent/ Forelimb	Snout-vent/ Hindlimb
Ball's Pyramid .. (2)	145–147 (146·0)	9–11 (10·0)	2·29–2·47 (2·38)	2·58–2·71 (2·64)	2·00–2·28 (2·14)
Roach Island .. (10)	135–160 (146·3) S.D.=7·44	9–10 (9·9) S.D.=0·38	2·16–2·44 (2·32) S.D.=0·064	2·75–3·04 (2·89) S.D.=0·102	2·27–2·54 (2·39) S.D.=0·058
Rabbit Island .. (9)	136–153 (142·2) S.D.=6·97	10–12 (11·0)	2·17–2·43 (2·27) S.D.=0·059	2·91–3·70 (3·27) S.D.=0·261	2·41–2·74 (2·58) S.D.=0·233
Lord Howe Island⁽¹⁾ (8)	137–147 (139·2) S.D.=4·38	10 (10·0)	2·18–2·90 (2·40) S.D.=0·225	2·66–3·17 (2·94) S.D.=0·154	2·28–2·58 (2·44) S.D.=0·088
Lord Howe Island⁽²⁾ (28)	135–160 (143·7) S.D.=6·79	9–12 (10·14) S.D.=0·77	2·16–2·90 (2·33) S.D.=0·132	2·58–3·70 (3·01) S.D.=0·255	2·00–2·74 (2·45) S.D.=0·294
Norfolk Island .. (24)	119–140 (133·7) S.D.=4·82	9–12 (10·24) S.D.=0·90	2·00–2·51 (2·19) S.D.=0·111	2·84–3·59 (3·13) S.D.=0·181	2·14–2·75 (2·50) S.D.=0·163

(1) Main island only.

(2) Lord Howe Island and off-shore island specimens pooled.

The relationship between *P. guentheri* and *P. affinis* (the latter known only from the New Hebrides) is obscure. Miss Grandison kindly examined the holotype of *P. affinis* and found numerous differences in scalation between the two species. It would therefore seem advisable to leave any assessment of these differences until additional specimens of *P. affinis* are available.

LOCAL DISTRIBUTION AND ECOLOGY

The first report on the habits of the lizards of Lord Howe Island was that of Etheridge (1889), who stated of *Phyllodactylus guentheri* and *Lygosoma lichenigera* that they " . . . may be sought for on dry stony ground, under stones, amongst dry leaves, and at the feet of low scrubby trees." Ogilby (1889) states simply that both species are " . . . much more abundant in the vicinity of the coast than on the more elevated districts inland." Etheridge (1889) goes on to say that " . . . so far as our researches enabled us to judge, *Phyllodactylus guentheri* is the commonest, the distribution of this and the other species (*L. lichenigerum*) being very general, not only on the main island, but also on Goat (=Rabbit) Island and the Admiralty Islets."

No further general account of the reptiles was given until that of Paramonov (1960), who, although he did not mention Etheridge's paper, nevertheless quoted the latter precisely. However, in doing so he made the error of applying Etheridge's comments on habitat to all three species, instead of the two species to which Etheridge originally and correctly referred. For reasons outlined above the inclusion of *Gehyra oceanica* was probably in error.

It is significant that despite the fact that no zoologist had previously visited Lord Howe Island for the express purpose of collecting reptiles, small collections have nevertheless been obtained apparently with little difficulty. The Australian Museum possesses several small series of specimens collected at various times between 1888 and 1963. Except for the series collected in 1962–63 from Rabbit Island, all earlier specimens have the locality of " Lord Howe Island ". As the prime reason for the visit of an Australian Museum party in 1909 was to obtain bird specimens from the Admiralty Islets for a Museum exhibit, it seems likely that at least some of our lizards were taken from those islets and not from the main island.

Loveridge (1934) states that a series of specimens of *L. cuprea* (=*L. lichenigera*) in the Museum of Comparative Zoology was collected by Mr. R. Baxter in 1932. These specimens were taken when they fell into a drum set into the ground and baited with fish oil, and K. R. Hindwood (*in litt.*) reports that Baxter informed him that these specimens were taken on Rabbit Island after unsuccessful attempts to collect lizards on the main island. A specimen (R768) of *L. lichenigera* in the Dominion Museum, Wellington, collected by W. R. B. Oliver in 1913, has the notation " north end Lord Howe Island ".

From this scant evidence there seems little doubt that both species—*Phyllodactylus guentheri* and *Leiolopisma lichenigera*—were once common and easily procured on the main island, as well as on the off-shore islands, and it was with this background information that the writer set out to assess the present distribution of reptiles on Lord Howe Island.

The results were disappointing. Despite a search of all major available habitats, especially those in which earlier workers had reported finding lizards, not a single specimen was obtained. Although some habitats, such as the leafy heads of the *Howea* palms, were virtually inaccessible, all terrestrial habitats were examined. Three major saxicoline environments are present on the main island :

(1) Covering the greater portion of the island are outcrops of basaltic volcanic rocks, in the form of either solid rock faces or boulder slopes. All of the major topographic features are made up of this rock, as are all of the off-shore islands.

(2) Recent sediments, which form a stratified " sandstone ", outcrop in several places, the most prominent being above Ned's Beach on the eastern side of the island.

(3) The only other rock consists of large clumps of old " beach rock ", which may be loosely or firmly embedded in soil, and which outcrop in several places on the lower parts of the island.

The first of these three rocky environments corresponds with the " North Ridge Volcanics " and " Mt. Lidgbird Volcanics " of Standard's (1963) geological map of the island. The second corresponds with his " Ned's Beach Calcarenite " and the third with his " Alluvium, including beach and talus deposits ". The age and distribution of each of these are shown on Standard's map.

On the main island a search of the basalt rock faces and slopes failed to reveal a single lizard. Collecting efforts were concentrated at four points :

1. The boulder slopes below Mt. Lidgbird, immediately behind Salmon Beach.
2. The slopes of Dawson Ridge, between Old Settlement Bay and North Bay.
3. The lower, eastern slopes of Malabar.
4. The northern slopes of Intermediate Hill.

Also, although the search was far from exhaustive, a search was nonetheless carried out along the track from Salmon Beach to the summit of Mount Gower and in the " moss forest " which occupies several hundred acres on the summit of that mountain.

All of these searches failed to find any trace of lizards, either among rocks or in or under fallen logs. No sloughs were found ; nor eggs or egg shells.

Following reported sightings of lizards, the area behind Ned's Beach was also searched carefully, especially in the stratified " sandstone " which makes up much of the headland (Stevens Point) between Ned's Beach and Middle Beach. No lizards were found.

During the time that this work was being carried out, a cyclone prevented the author from reaching any of the off-shore islands. As soon as the weather cleared a visit was made to Rabbit Island, where both *Phyllodactylus guentheri* and *Leiolopisma lichenigera* were found commonly under loose basalt boulders. Small slopes of these loose boulders occurred mainly on the leeward (northern) side of the island, especially around the bases of low, windswept trees. On the windward side of the island few loose boulders occurred but an examination of large crevices in outcrops of rock revealed traces (a mummified body and sloughed skins) of both species.

As the island is so small, and as the Australian Museum already possessed samples from Rabbit Island, only a small number of specimens were actually taken. Although unlikely, it is nevertheless quite possible that the removal of large numbers of lizards could have a decimating effect on the total population. Of the lizards found, the ratio of *L. lichenigera* to *P. guentheri* was 4 : 1.

Subsequently, attempts were made to land on two of the other off-shore islands—Mutton Bird Island, off the eastern shore, and Roach Island, the largest of the Admiralty group of islands off the southern point of the main island. Both of these islands are surrounded by rocky shores, and although heavy seas prevented a landing on Mutton Bird Island, the author was put ashore on Admiralty Islet, where collecting was carried out for about an hour before rising seas forced a hurried and wet return to the boat. During this hour 19 specimens were collected among large basalt boulders, in the ratio of 11 *P. guentheri* to 8 *L. lichenigera*. Both species were evidently extremely abundant.

It should be stressed that the lizards taken on Rabbit Island and on Admiralty Islet were found in a habitat which had proved completely barren of lizards on the main island.

About half-way through the author's visit to Lord Howe Island he was presented with a live specimen of *L. lichenigera* by Mr. R. Payton, whose cat had apparently caught the lizard in the vicinity of the Payton house. The latter is situated behind Lagoon Beach, just below Signal Point. In the following week the cat produced three more specimens of the same species. The area in which these lizards were taken consists of dense *Howea* palm forest with leaf-litter and scattered clumps of weathered " sandstone " embedded in the soil. The nature and origin of this rock is discussed below.

In a similar area, at the base of Malabar, the author searched among similar " sandstone " boulders and found a specimen of *P. guentheri* which entered one of the numerous finger-sized tunnels in a massive clump of the rock. The gecko could not be extricated from the rock but in some of the shallow holes clusters of eggs were found, some of which contained advanced living embryos of *P. guentheri*.

Subsequently, a sledge-hammer and crowbar were used unsuccessfully in an attempt to break up some of these sandstone clumps in the areas below Malabar and behind Lagoon Beach. Only the thinner surface layers of the stone could be broken up, leaving intact the massive bases, with their network of tunnels. No adult lizards were obtained but some hundreds of old and new gecko eggs were found, some with well-developed living embryos.

This habitat warrants description in greater detail, as it is apparently the only habitat on the main island in which both species of lizards now occur. It consists of large irregularly-shaped boulders of honeycombed " rock " which may be either superficially or deeply embedded in the soil (Pl. I, D).

These boulders almost invariably outcrop in dense *Howea* palm forest, in which there is a thick mat of humus formed by palm and other leaf-litter. The matrix of the boulders consists of a " sandstone " or conglomerate sediment, and there seems little doubt that the outcrops are of weathered " beach rock ", a common formation of many coral reefs and the structure and origin of which is discussed fully by Wiens (1962). According to Standard (1963) these outcrops represent recent beach alluvium.

Of special significance in the ecology of the lizards on Lord Howe Island is the mode of weathering of these alluvial boulders. Their surfaces are deeply pitted with small holes, averaging only 1–2 cm. in diameter. These are the entrances to tunnels which enter deeply into the matrix of the rock. Such tunnels may coalesce to form larger chambers, as shown in Pl. II, A, B. The origin of these tunnels is uncertain, but they so closely resemble in structure the " subaerial solution potholes " observed in some limestones (Cotton, 1948, p. 448) that their origin might well be identical, especially as buried portions of these boulders are as strongly weathered as the exposed portions. Lord Howe Island has a relatively high average annual rainfall (68 inches) and the deeply-shaded floor of the *Howea* forests is normally quite moist. The exposed surfaces of the outcropping beach rock are covered with a layer of algae which imparts a distinctive green colour to the rock.

The role of the weathered tunnels or potholes in the ecology of the two lizards on Lord Howe Island seems to be that they provide a niche which is safe from virtually all predators, for the size of the openings precludes the entry of any of the island's predatory vertebrates. The tunnels offer an ideal site for the safe deposition of eggs (Pl. II, A) while insect food, both in the tunnels and in the surrounding leaf-litter, is abundant. The eggs of *Phyllodactylus guentheri* may be found in large numbers within the tunnels, recent clutches being deposited upon the hatched, empty shells of earlier seasons (Pl. II, B).

Apart from those eggs broken or immediately preserved, a series of five intact and apparently fertile eggs were brought back to the Australian Museum. There they were placed on paper in a dry glass jar, and left on a laboratory bench, where they were subject to a mean temperature of approximately 70° F. (range 66° F.–84° F.). As none had hatched by the end of December 1966 (the eggs having been collected in June 1966), they were no longer examined regularly and were put to one side. When next examined on 18th January 1967 two of the eggs had hatched. Both hatchlings were dead, one freshly so but it was possible to place the date of hatching within the two-week period preceding the 18th. Another egg hatched on 8th February, another on 13th February and another on 14th March. The mean snout-vent length of hatchlings was 30·25 mm.

The eggs of *P. guentheri* have thick, brittle calcareous shells which are apparently quite soft when laid, for they take the shape of the surfaces with which they come into contact when laid. Eggs are often found firmly adhering to one another or to the surface of a rock.

The significance of this long incubation time is not known. As it was not possible to know how long the eggs had been laid when collected, the minimum incubation time for those eggs collected varied from 30 to 39 weeks. Although overwintering of eggs is a relatively common phenomenon in lizards, the observations made above are not explicable in normal overwintering terms. The eggs were collected in mid-winter (when no gravid females were collected) and continued to develop throughout the spring and summer. Indeed, the last egg to hatch did so at the end of summer. The temperature of development in the laboratory was probably not very different from that experienced by eggs in the field during this period.

From these meagre observations it would be unwise to draw any general conclusions regarding incubation times or their roles in the biology and ecology of this lizard. These observations do indicate, however, that the reproductive habits of Lord Howe Island reptiles may differ radically from those of related forms on the Australian mainland.

On returning to Sydney, the author contacted Mr. David Rootes, a member of several climbing parties which attempted to scale Ball's Pyramid. Mr. Rootes advised that one species of lizard had been seen, and produced several photographs showing clearly an individual of *L. lichenigera.* This individual was observed to roll a tern egg down a rock slope until it broke, then fed on the contents.

Mr. Rootes' observations were made in November, whereas no lizards were active in the open during the author's visit to Lord Howe Island in winter (June).

SUMMARY

(1) The recent reptile fauna of Lord Howe Island comprises two species of lizards, the gecko *Phyllodactylus guentheri* and the endemic skink *Leiolopisma lichenigera.* The latter is resurrected from the synonymy of *Leiolopisma cuprea*, which is in turn relegated to the status of a *nomen dubium.* It has been shown that earlier records of the gecko *Gehyra oceanica* from Lord Howe Island were probably in error.

(2) On the small islands lying off-shore from Lord Howe Island the lizards occur commonly in the rocky habitat described by earlier workers. On the main island, however, both species appear to have virtually disappeared from the habitat in which they were once common and are now to be found only in a very restricted and specialized habitat consisting of weathered boulders of " sandstone " or " beach rock ". It seems likely that this habitat is the only one which offers protection from such introduced predators as rats.

(3) Slight differences in the proportions of the two lizards on different islands, differences in size, and the prolonged incubation period of the eggs of *Phyllodactylus guentheri* indicate the potential value of the reptile fauna of Lord Howe Island for future ecological and evolutionary studies.

ADDENDUM

Since this paper was submitted for publication the types of *Phyllodactylus guentheri* and *P. affinis* have been examined in the British Museum (Natural History). The *P. guentheri* syntype from Champion Bay is indeed conspecific with the other syntypes, and I therefore regard its locality data as incorrect. The holotype of *P. affinis* (B.M.N.H. 55.8.16.5.) appears to be a typical example of the Australian *Phyllodactylus marmoratus*, for which reason I suggest that its type locality (New Hebrides) is also incorrect.

Further to my comments on the ecology of *Leiolopisma lichenigera*, Dr. H. Recher reports (pers. comm.) that in summer this species is abundant and active at night among supralittoral rocks and other ground cover on Rabbit Island.

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References

Brown, W. C., 1953.—Results of the Archbold Expeditions. No. 69. A Review of New Guinea Lizards Allied to *Emoia baudini* and *Emoia physicae*. *Amer. Mus. Novit.*, No. 1627, pp. 1–25.

————, 1954.—Notes on several lizards of the genus *Emoia*, with descriptions of new species from the Solomon Islands. *Fieldiana : Zoology*, 34 (25) : 263–276.

Boulenger, G. A., 1885.—Cat. Liz. Brit. Mus. (N.H.), 1, British Museum (N.H.), London.

————, 1887.—Cat. Liz. Brit. Mus. (N.H.), 3, British Museum (N.H.), London.

Cotton, C. A., 1948.—Landscape. As developed by the processes of normal erosion. 2nd Ed., Whitcombe and Tombs Ltd., Christchurch, pp. 1–509.

Etheridge, R., 1889.—The General Zoology of Lord Howe Island, *in* Lord Howe Island. Its Zoology, Geology and Physical Characters. *Memoirs Aust. Mus.*, 2 (1) : 3–42.

Gurney, A. B., 1947.—Notes on some remarkable Australian walkingsticks, including a synopsis of the genus *Extatosoma* (Orthoptera : Phasmatidae). *Ann. ent. Soc. Amer.*, 40 : 373–396.

Hindwood, K. A., 1940.—The birds of Lord Howe Island. *Emu*, 40 : 1–86.

————, and Cunningham, J. M., 1950.—Notes on the birds of Lord Howe Island. *Emu*, 50 : 23–35.

Loveridge, A., 1934.—Australian Reptiles in the Museum of Comparative Zoology, Cambridge, Massachusetts. *Bull. Mus. Comp. Zool., Harv.*, 77 (6) : 243–383.

MacGillivray, J., 1852–55.—Voyage of H.M.S. Herald, under command of Captain H. Mangles Denham R.N. being Private Journal kept by John MacGillivray, Naturalist. Mss. No. 23, Admiralty Library, London.

McAlpine, D. K., 1966.—Rediscovery of Lord Howe Island Phasmid. *Aust. ent. Soc. News Bull.*, 2 (3) : 71.

McCann, C., 1955.—The Lizards of New Zealand. Gekkonidae and Scincidae. *Bull. Dom. Mus.*, 17 : i-viii, 1–127.

McCulloch, A. R., 1921.—Lord Howe Island—A Naturalist's Paradise. *Aust. Mus. Mag.*, 1 (2) : 31–47.

McKean, J. L., and Hindwood, K. A., 1965.—Additional Notes on the Birds of Lord Howe Island. *Emu*, 64 (2) : 79–97.

Mitchell, F. J., 1965.—Australian geckos assigned to the genus *Gehyra* Gray (Reptilia : Gekkonidae). *Senck. biol.*, 46 (4) : 287–319.

Nicholls, Max, 1938.—Lord Howe Island, 1788–1938. George M. Dash, Sydney, pp. 1–76.

Ogilby, J. D., 1889.—The Reptiles and Fishes of Lord Howe Island, *in* Lord Howe Island. Its Zoology. Geology and Physical Characters. *Memoirs Aust. Mus.*, 2 (3) : 51–74.

Oliver, W. R. B., 1917.—The Vegetation and Flora of Lord Howe Island. *Trans. N. Zeal. Instit.*, 49 : 94–161.

Paramonov, S. J., 1958.—Lord Howe Island, a Riddle of the Pacific. *Pacific Science*, 12 (1) : 82–91.

————, 1960.—Lord Howe Island, a Riddle of the Pacific. Part II. *Pacific Science*, 14 (1) : 75–85.

————, 1963.—Lord Howe Island, a Riddle of the Pacific. *Pacific Science*, 17 (3) : 361–373.

Phillip, Arthur, 1789.—The Voyage of Governor Phillip to Botany Bay . . . compiled from Authentic Papers . . . etc. John Stockdale, London.

Pope, E. C., 1949.—A Naturalist on Lord Howe Island, Part I. *Wild Life*, 12 (11) : 549–554.

————, 1959.—Lord Howe Island, Ch. 10 *in* The Great Barrier Reef and Adjacent Isles (by K. Gillett and F. McNeill), Coral Press, Sydney, pp. 141–159.

————, 1960.—The Natural History of Lord Howe Island. *Aust. Mus. Mag.*, 13 (7) : 207–210.

Squires, D. F., 1963.—Carbon-14 Dating of the Fossil Dune Sequence, Lord Howe Island. *Aust. J. Science*, 25 (9) : 412–413.

Standard, J. C., 1961.—Submarine Geology of the Tasman Sea. *Bull. Geol. Soc. Amer.*, 72 : 1777–1788.

————, 1963.—Geology of Lord Howe Island. *Jour. and Proc. Roy. Soc. N.S.W.*, 96 : 107–121.

Wiens, H. J., 1962.—Atoll Environment and Ecology. Yale University Press, New Haven, pp. i-xxii, 1–532.

Zietz, F. R., 1920.—Catalogue of Australian Lizards. *Rec. S. Austral. Mus.*, 1 : 181–228.

EXPLANATION OF PLATES

PLATE I

A. Lord Howe Island viewed from Malabar, showing Mt. Lidgbird (left) and Mt. Gower.

B. Northern, low-lying parts of Lord Howe Island viewed from the summit of Mt. Gower ; Rabbit Island is seen lying in the lagoon while the Admiralty Islands are in the right upper corner.

C. Rabbit Island from Lagoon Beach.

D. Clump of " beach rock " riddled with tunnels in which the eggs of *Phyllodactylus guentheri* are laid.

PLATE II

A and B. Sections of " beach rock " showing successive clutches of eggs of *Phyllodactylus guentheri* laid within tunnels.

C. *Leiolopisma lichenigera.*

D. *Phyllodactylus guentheri.*